Mapping Evidence of the Presence of Neotropical River Otter (*Lontra longicaudis*) in the rivers Peñas Blancas and Peñas Blanquitas in the Alexander Skutch Biological Corridor in Southwestern Costa Rica Using Camera-Traps, T.E.K., and a Field Survey.

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Foreword

My Area of Concentration focuses on using traditional ecological knowledge, community participation, GIS, and ecology for conservation. At the start of my degree I wanted to learn about community-based sustainable resource use and conservation because during my Undergraduate degree I was only taught top-down methods of conservation such as protected areas. I saw many problems with government regulation of resources and human exclusion from their traditional territories, and I wanted to explore grassroots alternatives to conservation and resource management. I also came to York with the intention of learning how to use GIS and remote sensing software because I recognized their value in conservation, resource management, international developments, and landscape planning. My research incorporated the components of my plan of study: Conservation, Indigenous Knowledge Systems, and GIS by using GIS to visualize community accounts of a threatened Neotropical river otter (*Lontra Longicaudis*). My research will provide evidence of the presence of this species in two rivers: Rio Peñas Blancas and Rio Peñas Blanquitas in the Alexander Skutch Biological Corridor in southwestern Costa Rica.

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An Introduction: Context for the Research Project

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The Alexander Skutch Biological Corridor (ASBC) is a small group of agricultural communities in Southwestern Costa Rica near the city of San Isidro del General. These communities applied for the designation of Biological Corridor in 2005, with the support of the Tropical Science Center of Costa Rica and York University of Canada (Montoya-Greenheck, personal communication 2016), and have strived to maintain their lands to encourage the safe passage of wildlife from the mountainous national parks in the Northeast and their surroundings (Martinez and Saker 2012). An example the incentives provided to, but not limited to, the ASBC communities is the government program "Pago Por Servicios Ambientales" (Martinez and Saker 2012) that provides monetary compensation to land owners who commit to maintaining and/or increasing forest density on their properties. Those who join this program agree to refrain from extracting lumber or other forest product from their land and to protect their forest from outside prospects (Malavasi et al. 2003). These communities have demonstrated their commitment to biodiversity and a healthy environment and thus are prime candidates for community-based conservation projects.

In 2012 a number of stakeholders, including the Solis family of the Costa Rican political party in power "Partido Accion Ciudadana", proposed the construction of a hydroelectric dam on the Rio Peñas Blancas which runs from Chirripó national park and down through ASBC. Despite Costa Rica's self-reliance in energy production the national government supported the project to increase revenues through the sale electricity to Panamá (Montoya-Greenheck, personal communication, 2016). The proposed project threatened to leave the communities with only 15% of the original river flow, which would dry the river for if not most of the year, then permanently. The community was outraged, and could not believe that this could occur within a biological corridor. Locals feared for the future of their biological corridor (Monge, personal communication, 2016).

According to a conversation I had on February 10th 2016 with Luis Monge, a member of the ASBC community of Santa Elena, a small group of community members, including Monge, came together to form an activist group called the "Movimiento Rios Vivos" to resist against the hydroelectric projects. Although powerless at first, the group both met regularly and invested their own savings in research and to familiarize themselves with the legal process. Within six months the group created an influential document that supported their claims; citing environmental and biological research from the area, the document underlined how the project would be detrimental to both the area value and its biodiversity. According to Luis Monge "the hydroelectric company was a front for a series of rich, powerful, politicians." This political situation created support for the project: experts were hired to defend the project with claims that the corridor was not of exceptional biological value. The community members were victorious in this debate when one project was abandoned and a second was archived. Despite the victory, the group continues to convene and attend national meetings to maintain their presence. Although they are confident in their ability to combat future proposals the communities in ASBC continue to believe their river is threatened (Monge, personal communication, 2016). My research focused on determining the presence or absence of the Neotropical river otter (*Lontra longicaudis*) in the rivers inside the Alexander Skutch Biological Corridor and to map their distribution. The threat that human interference has on the fragile population of the Neotropical river otter provides ASBC with leverage in their defense against future hydroelectric projects. The river otter is an exemplar species for this leverage for three reasons: first, they are protected by both the IUCN and Costa Rican list of endangered species (Alarcon and Simoes-Lopes 2003, Quadros and Filho 2002, Schipper et al. 2008); second, their existence and persistence in Costa Rica is dependent on the river for both territory and shelter and they demonstrate preference for pristine habitats (Pardini 1998, Pardini and Trajano 1999, Kasper et al. 2008); third, they are a population of apex predators whose presence can be used to judge the health of other species' populations in the watershed (Pardini 1998, Quadros and Filho 2002, Pardini and Trajano 1999).

This paper is presented in three sections. This first section (Introduction) a) will provide background on river otter ecology and b) a brief review of Traditional Ecological Knowledge. The second section is a stand-alone paper on the community interviews on river otters. The third section is a stand-alone research note on the use of camera traps in studying river otters in ASBC

Otter Ecology

Otters are semi-aquatic mustelids found in both freshwater and marine coastal environments of every continent with the exception of Antarctica and Australia (Mason and Macdonald 1986). They are carnivorous predators whose diet consists primarily of fish and crustaceans (Pardini 1998, Rheingantz et al. 2011, Gori et al. 2003, Alarcon and Simoes-Lopes 2004, Kasper et al. 2008). Otter populations are largely considered threatened because of the value of their pelts and because they are often perceived as pests (Mason and Macdonals 1986, Dong et al 2010). In relation to its Eurasian, African and North American relatives, little is known about South American otter species' feeding habits and ecology (Ker de Andrade 1997). Out of the South American species, the Neotropical river otter (*Lontra longicaudis*) is most data deficient, despite ranging from Mexico, through Central America and down to Uruguay (Pardini 1998, Chehebar 1990, Quadros and Monteiro-Filho 2002, Rheingantz et al. 2011). The precautionary principle has been invoked by the IUCN and home countries due to this lack of data thus this species is considered threatened (Alarcon and Simoes-Lopes 2003, Quadros and Monteiro-Filho 2002, Schipper et al. 2008). In this brief review, I provide background information on behavior, habitat use and diet for Neotropical river otters or closely related species.

River otters are diurnal species that require naturally occurring or self-excavated shelters near water to use as refuge (Pardini and Trajano 1999, Kasper et al. 2008). Females also use these shelters to give birth to and protect their young (Quadros and Monteiro-Filho 2002). River otters prefer environments with dense forest and riverbanks lined with boulders and large trees whose exposed roots form cavities to build shelters (Casariego-Madorell et al. 2006). Neotropical river otters are nomadic, rotating shelters every few days (Quadros and Monteiro-Filho 2002). Unrelated individuals may share refuges however never at the same time. Scat, used as a scent marker, suggests otters center their activities around their dens (Mason and Macdonald 1986, Quadros and Monteiro-Filho 2002), but this is controversial as it was not evident in other studies (Pardini and Trajano 1999, Kasper et al. 2008). Despite the plasticity with which the otter choose shelters, they demonstrate preference to certain dens that they use frequently throughout the year. For example, dens that are located higher relative to water level are preferred due to lower flood risks (Pardini and Trajano 1999, Kasper et al 2008, Quadros and Monteiro-Filho 2002). In addition to choosing habitat based on shelter availability most species of otter concentrate their activities in areas where water pools surrounded by abundant riparian vegetation cover. It is suspected that otter prefer these pools because a greater diversity of aquatic species can be found there (Carillo-Rubio and Lafon 2004) which for the carnivorous otter means a diverse supply of prey.

River otters are negatively affected by human disturbance, but may adapt to low intensity agriculture provided that there is sufficient vegetation and a wealth of possible refuges and prey (Madina-Vogel et al 2003, Krukk 2006, Mason and Macdonald 1986, Pardini and Trajano 1999, Gomez et al. 2014). Although some agriculture is adaptable cattle grazing can especially degrade the otter habitat because the damage to vegetation prevents floral regeneration (Carillo-Rubio and Lafon 2004). Although Pardini and Trajano (1999) found no variance in the distribution and use of shelters between human dominated and pristine habitats, more recent research, which demonstrates the close relation between the otter and it's habitat, suggests that destructive human activity in an otter's habitat can have severe effects on their fragile population (Medina-Vogel et al. 2003, Carillo-Rubio and Lafon 2004).

River otter are elusive and their behavior and population density are often estimated through the distribution of their scat (spraint) (Quadros and Monteiro-Filho 2002, Pardini 1998, Pardini and Trajano 1999, Krukk et al. 1986, Alarcon and Simoes-Lopes 2003, Elmeros and Bussenius 2002, Gallo 1986, Gonzalez and Utrera 2004, Gomez et al. 2014). Quadros and Monteiro-Filho (2002) argue that spraint was concentrated in and around dens to mark territory and can be used to estimate population size based on territorial markings. Kruuk et al. (1986) and Pardini and Trajano (1999) however found no correlation between spraint frequency and territory. Alarcon and Simoes-Lopes (2003) argue that spraint frequency can be an indication of population fitness instead of population density. Furthermore, Krukk and Conroy (1987) suggest that spraint frequency is subject to different behavioral or seasonal effects thus making it difficult to use spraint to gauge otter population. Researchers (Pardini and Trajano 1999, Alarcon and Simoes-Lopes 2003) propose that the number of shelters may correlate with population density.

The Neotropical river otter diet varies both seasonally and across habitats. Although fish and crustaceans are primarily consumed, they also consume insects, amphibians, reptiles, mammals, and in some circumstances birds (Ker de Andrade 1997, Pardini 1998, Krukk 2006, Rheingantz et al. 2011, Gori 2003, Mason and Macdonald 1986). There is a dietary split between New World *Lontra* otter and Old World *Lutra* otter where the former will supplement their diets with invertebrates, and the latter prefer other vertebrate species, which can be explained by an evolution in dentition (Pardini 1998). The diet and amount of prey consumed seasonally fluctuates with prey availability and. in the dry season, when fish are scarce, insects and amphibians become more prominent in the Neotropical river otter's diet (Pardini 1998, Rheingantz et al. 2011). In contrast, these organisms are almost not consumed at all during the rainy season (Pardini, 1998) but Ker de Andrade (1997) found more prey consumed during rainy season.

While researchers generally agree on the composition of the Neotropical river otter's diet one problem with research conducted is the reliance on spraint. For example without genetic confirmations it is difficult to confidently identify which species deposited the scat (Davison et al. 2002). Positive identifications can be a result of observational biases such as confirmation bias (Nickerson 1998). Diet studies that use scat analysis come with a set of challenges. First, there is the issue of independent spraint samples without genetically identifying individuals in the study population (Davison et al. 2002). Second, prey species digest at different rates and therefore may be under represented (Reynolds and Aebischer 1991). Third, prey remnants may be distributed across different scats (Dellinger and Trillmich 1988), skewing results of dietary proportions. Despite gaps in the data produced, dietary analysis of scat samples is often preferred because of its non-invasiveness (Rheingantz et al. 2011, Mason and Macdonald 1986). More invasive methods involve the analysis of, gut content, stable isotopes from tissue samples, or fatty acid from the animals' fat cells (Mason and Macdonals 1986, Dellinger and Trillmich 1988, Stenson et al. 1984, Szepanski et al. 1999, Iverson et al. 2004).

The otters' vulnerability to the stochastic events that occur in river systems make river otters a good indicator species for river ecosystem health because they are sensitive to habitat degradation and require high quality river habitats to persist (Casariego-Madorell et al. 2006). River otter are apex predators with very strict environmental constraints and preferences that can indicate the health of their ecosystem. The plastic nature of their diet can be studied to understand differences in prey availability. Their distribution can also be used to assess habitat quality, as they have demonstrated a preference for pristine forest environments.

Community-Based Resource Management and TEK

Ecology is the study of living organisms and their interactions with the biotic and abiotic world (Odum and Barrett 1971). The discipline outlines the web of interconnecting processes that link every part of the ecosystem. Although ecology is a branch of contemporary science, complied through systematic observations, some believe that this information can be derived from the accumulation of everyday observations of one's surrounding environment, usually passed down through generations in the form of tradition (Berkes 1999[1], Berkes et al. 2000,). The study of traditional ecological knowledge (T.E.K.) is based on trans-generational ecological information being transferred by beliefs and social norms that are the consequence of historical experience and that guide the sustainable practices and biodiversity stewardship often characteristic to these communities (Huntington 1998, Inglis 1993, Berkes 1999[1], Turner et al 2000). T.E.K is therefore cumulative and adaptive. It is an epistemology that is not exclusively Indigenous as many societies exist that acquire T.E.K. as consequence of subsistence (Berkes 1999[2], Inglis 1993).

T.E.K suggests that it is possible to believe that local communities may be able to manage their own natural resources sustainably (Turner et al. 2000). Local communities have more at stake in the management of their own resources than a state or corporation does. They are more aware of the ecological processes that occur on their land (Langton 2003), and may enforce environmental protection more effectively through traditional means. Empowering local communities therefore should yield better results than applying policy changes and enforcing laws (Brosius et al. 2005). In order for a community based resource management program to work locals must be given a great deal of autonomy, or at least equal voice in decision-making and programs must ensure benefit to the community in order to incite their participation (McGregor 2009).

It is often difficult for local communities to obtain a voice in the management of their resources because they often lack the language and tools to speak to those who historically have denied them the right of inclusion (Stevenson 2006, Keck and Sikkink 1998). Underprivileged communities and individuals have put forth the effort to learn to use the vocabulary and technologies in order to gain respect in political arenas (Colchester 2005, Stevenson 2006), however, these tools come at a price as it is impossible to separate these tools from their historical context (Brosius et al. 2005). For example, maps are created to reflect the reality of the mapmaker. Official country maps often display forests and wild lands as empty and void of activity. In reality there are often communities that inhabit these areas. In this example, countermapping is the action that creates alternative maps that reflect the interest of these communities (Colechester 2005, Brosius et al. 2005).

As an option to level the playing field local communities may join forces with transnational activist agencies that are concerned with both human rights and environmental protection. Partnerships of this kind can provide locals with the resources they need to contend in the defense of their land and resources (Keck and Sikkink 1998, Brosius et al. 2005, McGregor 2009, Fairhead and Leach 2006, Johnstone 2010, Ros-Tonen et al. 2006). The partnerships often opt to exclude the state in favor of a more grassroots, bottom-up approach to resource management that comes from both equipping locals to do the work on their own and the power to make decisions for themselves (Colchester 2006). These agencies can provide lawyers, mapmakers, and capacity building programs that add credibility to their claims (Stevenson 2006, Keck and Sikkink 1998). They also bring with them both the capital that is more often than not lacking in local communities and a pluralistic perspective (Berkes 2007). Transnational advocacy agencies have the potential to extend the voices of subsistence communities but they may also smother it if the power is not equally distributed amongst professionals and local community members.

Community-based conservation and resource management are ideas that arose from grassroots partnerships with oppressed local communities (Otto et al. 2013). They come from the awareness that there is evidence from the locations of biodiversity hotspots, that subsistence and traditional societies may be best prepared to manage the use of their own resources (Brosius et al. 2005, Langton 2003). With the help of partners, locals are given access to both the technologies, such as G.I.S. software, and the capabilities to use them (Brosius et al. 2005). It is important however, to keep in mind when discussing international and national advocacy networks and partnerships that success and failure is not universal and that there is little replicability across locations because "environmental issues fit differently into different configurations of domestic political struggle" (Keck and Sikkink 1998, p162). Often the success of transnational advocacy networks depends on how the issue is framed, who the network chooses as allies, and the network's timing (Keck and Sikkink 1998, Berkes 2007).

The manuscript that follows explores the concept of community-based conservation and highlights that the communities in ASBC should be of interest for future conservation driven partnerships. I argue that to help alleviate locals' fears about the threat of future hydroelectric projects; community members from ASBC should put to use their knowledge about the Neotropical river otter. The people in these communities have compiled this knowledge through their numerous encounters with the species and from stories shared amongst locals, which I believe to be a form of T.E.K. I interviewed local fishermen to compile this traditional knowledge into a the following document that outlines the importance of the river system to the otter and other species that frequent the riverbanks. I also employed the practice of countermapping to geographically represent the realities of these locals, as current maps document neither the rivers Peñas Blancas and Peñas Blanquitas (with the exception of www.cobasvirtual.org) nor the local's use of the river. I follow this report with a short note about the efficacy of using camera-traps to document the presence of Neotropical river otter in ASBC.

References

Alarcon, G. G., & Simões-Lopes, P. C. (2003). Preserved versus degraded coastal environments: a case study of the Neotropical otter in the Environmental Protection Area of Anhatomirim, Southern Brazil. Group Bull,20(1), 6-18.

Alarcon, G. G., & Simões-Lopes, P. C. (2004). The Neotropical otter Lontra longicaudis feeding habits in a marine coastal area, Southern Brazil. IUCN Otter Spec. Group Bull, 21(1), 24-30.

Berkes, F. (1999)[1] "Context of Traditional Ecological Knowledge." Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Philadelphia, PA: Taylor & Francis. 1-19. Print.

Berkes, F. (1999)[2] "How Local Knowledge Develops: Cases from the West Indies." Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Philadelphia, PA: Taylor & Francis,. 1-19.

Berkes, F. (2007). Community-based conservation in a globalized world. Proceedings of the National academy of sciences, 104(39), 15188-15193.

Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. Ecological applications, 10(5), 1251-1262.

Brosius, J. P., A. Tsing, and C. Zerner.(2005). "Introduction: Raising Questions About Communities and Conservation." Communities and Conservation: Histories and Politics of Community-based Natural Resource Management. Walnut Creek, CA: AltaMira. 1-36.

Carrillo-Rubio, E., & Lafón, A. (2004). Neotropical River Otter Micro-Habitat Preference In West-Central Chihuahua, Mexico. IUCN Otter Spec. Group Bull,21(1), 10-15.

Casariego-Madorell, M. A., Sánchez, R. L., & González, G. C. (2006). Aspectos básicos sobre la ecología de la nutria de río (Lontra longicaudis annectens) para la costa de Oaxaca. Revista Mexicana De Mastozoologia. (Nueva Época), 10(1), 71-74.

Chehébar, C. E. (1985). A survey of the southern river otter Lutra provocax Thomas in Nahuel Huapi National Park, Argentina. Biological Conservation,32(4), 299-307.

Colchester, M. (2005)[1]. "Maps, power, and the defense of territory: the Upper Mazaruni land claim in Guyana." Communities and conservation: Histories and politics of community-based natural resource management (2005): 271-304.

Colchester, M. (2006). "Lessons from International Community Forestry Networks." Partnerships for Sustainable Forest and Tree Resource Management in Latin America. Leiden : Brill. 301-22.

Davison, A., Birks, J. D., Brookes, R. C., Braithwaite, T. C., & Messenger, J. E. (2002). On the origin of faeces: morphological versus molecular methods for surveying rare carnivores from their scats. Journal of Zoology, 257(2), 141-143.

Dellinger, T., & Trillmich, F. (1988). Estimating diet composition from scat analysis in otariid seals (Otariidae): is it reliable? Canadian Journal of Zoology, 66(8), 1865-1870.

Dong, T., Tep, M., Lim, S., Soun, S., & Chrin, T. (2010). Distribution of Otters in the Tropeang Roung, Koh Kong Province, Cambodia. IUCN Otter Specialist Group Bulletin, 27(2).

Elmeros, M., & Bussenius, N. (2002). Influence of Selection of Bank Side on the Standard Method for Otter Surveys. IUCN Otter Spec. Group Bull, 19(2), 67-74.

Fairhead, J., and M. Leach. (2006). "Partnerships for Sustainable Timber Production in Trinidad: Dealing with Social and Ecological Dynamics." Partnerships for Sustainable Forest and Tree Resource Management in Latin America. Leiden : Brill. 107-26.

Gallo, J. P. (1996). Distribution of the Neotropical river otter (Lutra longicaudis annectens Major, 1897) in the Rio Yaqui, Sonora, México. IUCN otter speciallist Group Bulletin, 13, 27-31.

González, I., & Utrera, A. (2004). Distribution of the Neotropical Otter Lontra longicaudis in the Venezuelan Andes: Habitat and Status of its Population IUCN Otter Spec. Group Bull, 21(2), 86-92.

Gomez, J. J., Túnez, J. I., Fracassi, N., & Cassini, M. H. (2014). Habitat suitability and anthropogenic correlates of Neotropical river otter (Lontra longicaudis) distribution. Journal of Mammalogy, 95(4), 824-833.

Gori, M., Carpaneto, G. M., & Ottino, P. (2003). Spatial distribution and diet of the Neotropical otter *Lontra longicaudis* in the Ibera Lake (northern Argentina).Acta theriológica, 48(4), 495-504.

Huntington, H. P. (2000). Using traditional ecological knowledge in science: methods and applications. Ecological applications, 10(5), 1270-1274.

Inglis, J. (1993). Traditional ecological knowledge: Concepts and cases. IDRC.

Iverson, S. J., Field, C., Don Bowen, W., & Blanchard, W. (2004). Quantitative fatty acid signature analysis: a new method of estimating predator diets. Ecological Monographs, 74(2), 211-235.

Johnstone, G. (2010). Building Partnerships. Rep. no. 57. Samudra Reports. 14-17. Web. http://mpa.icsf.net/en/page/806-SAMUDRA%20Report.html

Kasper, C. B., Bastazini, V. A. G., Salvi, J., & Grillo, H. C. Z. (2008). Trophic ecology and the use of shelters and latrines by the Neotropical otter (Lontra longicaudis) in the Taquari Valley, Southern Brazil. Iheringia. Série Zoologia, 98(4), 469-474.

Keck, M. E., and K. Sikkink. (1998). "Transnational Advocacy Networks in International Politics." Activists beyond Borders: Advocacy Networks in International Politics. Ithaca, NY: Cornell UP. 1-38.

Ker De Andrade, H. (1997). Food and feeding habits of the neotropical river otter Lontra longicaudis (Carnivora, Mustelidae). *Mammalia*, *61*(2), 193-204.

Kruuk, H. (2006). Otters: ecology, behaviour and conservation. Oxford University Press.

Kruuk, H., & Conroy, J. W. H. (1987). Surveying otter Lutra lutra populations: a discussion of problems with spraints. Biological Conservation, 41(3), 179-183.

Langton, M. (2003) "The 'Wild', the Market, and the Native: Indigenous People Face New Forms of Global Colonization." Globalization, Globalism, Environments and Environmentalism: Conceiving Connections. Oxford: Oxford UP. 141-70. Print

Malavasi, O., Mora, S. R., Borge, L. F., & Carvajal, C. (2003). Impacto del Programa de Pago de Servicios Ambientales en Costa Rica como medio de reducción de la pobreza en los medios rurales. San José, CR. 64p.

Martínez, A.M. & Saker, Chris. (2012). Las Nubes: Conservation in the Cloud Forests of Costa Rica. Rainforest Editions. York University Bookstore.

Mason, C. F., & Macdonald, S. M. (1986). Otters: ecology and conservation. Cambridge University Press.

McGregor, D. (2009). "Linking traditional knowledge and environmental practice in Ontario." Journal of Canadian Studies/Revue d'études canadiennes 43.3: 69-100.

Medina-Vogel, G., Kaufman, V. S., Monsalve, R., & Gomez, V. (2003). The influence of riparian vegetation, woody debris, stream morphology and human activity on the use of rivers by southern river otters in Lontra provocax in Chile.Oryx, 37(04), 422-430

Monge, L. Personal communication. February 10, 2016.

Montoya-Greenheck, F. Personal communication. July, 2016

Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. Review of general psychology, 2(2), 175.

Odum, E. P., & Barrett, G. W. (1971). Fundamentals of ecology (Vol. 3). Philadelphia: Saunders.

Otto, J., Zerner, C., Robinson, J., Donovan, R., Lavelle, M., Villarreal, R., ... & Pearl, M. (2013). Natural connections: perspectives in community-based conservation. Island Press.

Pardini, R. (1998). Feeding ecology of the neotropical river otter Lontra longicaudis in an Atlantic Forest stream, south‐eastern Brazil. Journal of Zoology, 245(4), 385-391.

Pardini, R., & Trajano, E. (1999). Use of shelters by the neotropical river otter (Lontra longicaudis) in an Atlantic forest stream, southeastern Brazil. Journal of Mammalogy, 80(2), 600-610.

Quadros, J., & Monteiro-Filho, E. L. A. (2002). Sprainting sites of the Neotropical otter, Lontra longicaudis, in an Atlantic Forest area of southern Brazil. Mastozoología neotropical, 9(1), 39-46.

Reynolds, J. C., & Aebischer, N. J. (1991). Comparison and quantification of carnivore diet by faecal analysis: a critique, with recommendations, based on a study of the fox Vulpes vulpes. Mammal Review, 21(3), 97-122.

Rheingantz, M. L., Waldemarin, H. F., Rodrigues, L., & Moulton, T. P. (2011). Seasonal and spatial differences in feeding habits of the Neotropical otter Lontra longicaudis (Carnivora: Mustelidae) in a coastal catchment of southeastern Brazil. Zoologia (Curitiba), 28(1), 37-44.

Reynolds, J. C., & Aebischer, N. J. (1991). Comparison and quantification of carnivore diet by fecal analysis: a critique, with recommendations, based on a study of the fox Vulpes vulpes. Mammal Review, 21(3), 97-122.

Ros-Tonen, Mirjam AF, Heleen van den Hombergh, and Annelies Zoomers. " Partnerships in Sustainable Forest and Tree Resource Management in Latin America: The New Road Towards Successful Forest Governance?" Partnerships in Sustainable Forest Resource Management: Learning from Latin America (2006): 3.

Shipper, J., Hoffman, M., Duckworth, J. W., & Conroy, J. (2008). The 2008 IUCN red listings of the world's small carnivores. Small Carnivore Conservation, 39, 29-34.

Stenson, G.B., Badgero, O.A. ,and Fisher, H.D. (1984). Food habits of the river otter Lutra canadensis in the marine environment of British Columbia. Canadian Journal of Zoology, 62:88-91.

Stevenson, M. G. (2006). "The possibility of difference: rethinking co-management." Human Organization 65.2: 167-180.

Szepanski, M. M., Ben-David, M., & Van Ballenberghe, V. (1999). Assessment of anadromous salmon resources in the diet of the Alexander Archipelago wolf using stable isotope analysis. Oecologia, 120(3), 327-335.

Turner, N. J., Ignace, M. B., & Ignace, R. (2000). Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia. Ecological applications, 10(5), 1275-1287.

Mapping Neotropical River Otter (*Lontra longicaudis*) Activity in Peñas Blancas River System in the Alexander Skutch Biological Corridor of Costa Rica to Inform Future Conservation Strategies.

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Abstract

Community-based conservation initiatives are popular in the Alexander Skutch Biological Corridor (ASBC) due to partnerships with the Tropical Science Center of Costa Rica and with Canadian York University. This study compiled data about the presence of Neotropical river otter (*Lontra longicaudis*) in two rivers; Peñas Blancas and Peñas Blanquitas in the corridor through both interviews with local fishermen and a field survey. The results of this study confirm the presence of the species, both through observations by locals and encounters with otter signs. Implications of Neotropical river otter presence in ASBC include: indication of good river habitat quality, reason for further research and conservation initiatives that focus on the river system, tool to petition for increased water security for local communities. The results of the interviews indicate that the local communities in ASBC are valuable partners for biological conservation of their environment.

Iniciativas de conservación basadas en la comunidad son muy populares en el Corredor Biológico Alexander Skutch (ASBC) debido a su afiliación con el Centro Científico Tropical de Costa Rica y con la Universidad Canadiense York. Este estudio datos sobre la presencia de la nutria Neotropical (*Lontra longicaudis*) en dos ríos que se unen; Peñas Blancas y Peñas Blanquitas en el corredor a través de entrevistas con pescadores locales y un estudio de campo. Los resultados de este estudio confirman la presencia de la especie tanto a través de las observaciones de los locales y encuentros con signos de nutria. Implicaciones de la presencia de la nutria neotropical en ASBC incluyen: indicación de la buena calidad del hábitat del río, razón de más iniciativas de investigación y conservación que se centran en este sistema fluvial, herramienta de petición de aumento de la seguridad del agua para las comunidades locales. Los resultados de las entrevistas indican que las comunidades en ASBC son socios valiosos para la conservación biológica de su entorno.

Introduction

Community-based resource management projects seek to include local community participation in the management of their natural resources with the intention of reducing conflicts between local communities and resource management authorities (Leach et al. 1999). These kinds of resource management schemes are attentive to local human rights issues and attempt to find balance between community needs and protection of natural resources (Brosius et al. 1998). Similarly, community-based conservation describes projects for the protection of wildlife, habitat, and biodiversity that consider the livelihoods and lifestyles of surrounding local communities, which differ from traditional conservation initiatives for example, protected areas (Wells and Brandon 1993). These two concepts differ substantially in regards to strategies for participatory management with community based conservation standing to gain from the experiences of resource management plans (Campbell and Vainio-Mattila 2003). There is therefore a need to reassess biodiversity conservation plans to ensure that they include local participation in all stages of project development and management. Coupled with the idea that traditional ecological knowledge (T.E.K) is of value for informing wildlife conservation and habitat protection policies (Oviedo et al. 2004) it is imperative for the success of conservation projects that local communities be given a voice.

Otters are carnivorous mustelids that inhabit a broad spectrum of all aquatic environments worldwide with the exception of Oceania (Mason and Macdonald 1986). They have an adaptable diet but prey primarily on fish and crustaceans

(Pardini 1998). The Neotropical river otter (*Lontra longicaudis*), found from Mexico to Argentina (Mason and Macdonald 1986) despite being listed as data deficient in the IUCN Red List of Threatened Species (Carillo-Rubio and Lafon 2004), is more of a habitat generalist than the giant river otter (*Pteronura brasiliensis*) whose range overlaps in much of South America (Pardini and Trajano 1999). Neotropical river otters have a plastic diet comprised mainly of fish and crustaceans (Chemes et al. 2010) and make use of dens marked with scat, either naturally occurring or self-excavated, to both rear young and rest securely. An individual will inhabit multiple dens, and dens may be shared amongst individuals, although never at the same time unless by a mother and her cub (Pardini and Trajano 1999). The dens are found in either deep boroughs inside rocky shores or where dense vegetation occurs along small creeks (Gallo 1996). Neotropical river otter display the same habitat preferences as Eurasian freshwater otter species *(Lutra lutra)*: opting for benthic environments that include large rocks and boulders rather than sandy or muddy bottoms. They hunt close to the shore and prefer areas with low hanging vegetation (Kruuk 2006).

Rivers are subject to stochastic events, such as flooding and draught (Prowse et al. 2006), and anthropogenic land-use effects that degrade water quality (Malmqvisti and Rundle 2002, Mason and Macdonald 1986). These anthropogenic inputs resulting from land-use include, but are not limited to, water pollution, water level regulations, over harvesting, habitat degradation in ravine systems (Gomez et al 2014). Changes to the river, from both stochastic events and anthropogenic inputs, negatively impact populations of Neotropical river otters (Rheingantz and Trinca 2015). Thus river otters are a good indicator species for river ecosystem health because they require high quality river habitats to persist (Casariego-Madorell et al. 2006). River otters' effectiveness as an indicator species is further enhanced because as apex predators their diet mirrors the health of their prey's population (Gomez et al. 2014). Knowledge about the river otters' presence helps researchers better understand river ecology and contribute to the conservation of the species. Their preference for pristine, densely forested river systems, with low hanging vegetation on riverbanks, signals that conservation efforts will extend to the majority of the biological diversity of the system (Medina-Vogel 2003, Quadros and Monteiro-Filho 2002, Krukk 2006).

In this study I used interviews of local community members (Mason and Macdonald 1986) and countermapping approaches (Colchester 2005) to assess the presence, or absence, of Neotropical river otters in the two rivers, the Rio Peñas Blancas and the Rio Peñas Blanquitas southwestern Costa Rica. A group called "Movimiento Rios Vivos" (living rivers movement) was created in 2012 by local communities living on these rivers to both fight for local water rights and counter any project proposals (Monge, personal communication, 2016). The communities were interested in assessing the status of Neotropical river otters as leverage for increased water security and further otter conservation.

Study Area

Alexander Skutch Biological Corridor (ASBC) (see Figure 1) was designated a biological corridor because of local communities' concern for both biodiversity and environmental protection (Montoya-Greenheck, personal communication, 2016). The corridor communities are comprised of agriculturalists who spend up to ten hours a day working in the fields and who fish for leisure.

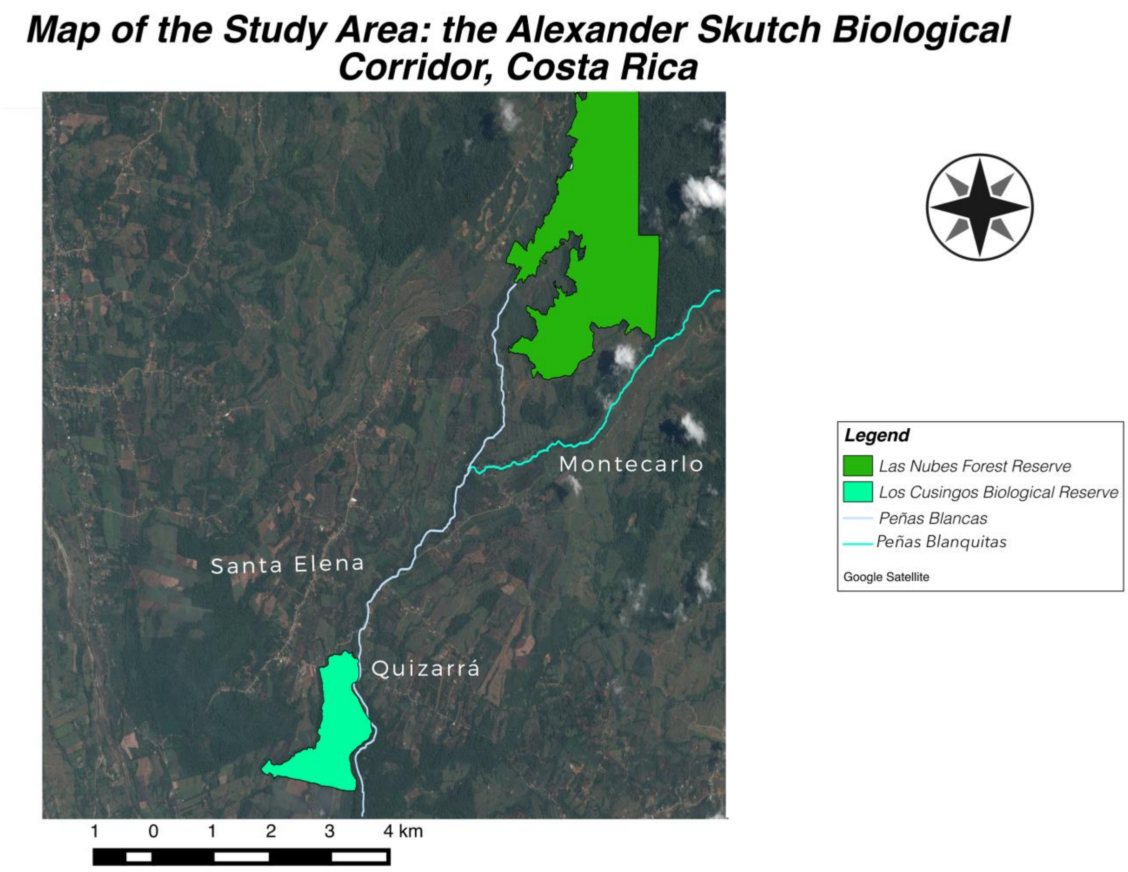

Figure 1: A map of the Alexander Skutch Biological Corridor displaying both the rivers Peñas Blancas and Peñas Blanquitas, and the two forest reserves; Los Cusingos Tropical Bird Sanctuary and Las Nubes Tropical Forest Reserve.

The rivers of interest, Rio Peñas Blancas and the adjoining Rio Peñas Blanquitas, are highlighted in Figure 1. Both of the rivers flow down from the Chirripó mountains at 9°24'N, 83°35'W and 9°22'N, 83°34'W respectively at elevations of over 1400m, through the corridor, before emptying into the Río San Ignacio at 9°18'N, 83°37'W and 614m. Neotropical river otter have been located in Chirripó National Park (Mooring et al. 2015, Mooring et al. 2011, Bryce 2011), that borders the Las Nubes Forest Reserve in the northeast edge of ASBC (Martinez and Saker 2012). Furthermore, Pacheco et al. (2006) recorded Neotropical river otter in San Vito, a town in the neighboring province of Puntarenas near the border with Panama, and Daily et al. (2003) recorded them in Las Cruces, which lies between San Vito and the corridor, but there are no formal records of the Neotropical river otter in either river of interest.

The study took place from February 2 2016 to March 27 2016, during the December to April dry season that causes the area to experience a drastic change in water level that is reflected in the floral and faunal lifecycles. The corridor contains several rivers and tributaries, of which Peñas Blancas and Peñas Blanquitas flow strongest. As these two rivers flow southwards, from the Crodillera Talamanca, they cut through the three communities of, Montecarlo, Santa Elena, and Quizarra, as well as the Las Nubes Forest Reserve, owned by York University, farm and residential lands, and past the Los Cusingos Biological Reserve (see Fig. 1).

Methods

The interview participants from the three previously mentioned communities, through which the two rivers pass, were selected according to a purposive sampling method (Ritchie et al. 2003) based on the amount of time they spent by the river: the more time spent around the river, the higher chance of being selected. An associate, who was both a member of the community and affiliated with York University suggested participants who were active fishermen. These participants were then used to recommend future participants (Noy 2008).

The interviews were guided by a questionnaire that focused on both the Neotropical river otter's lifestyle and on personal encounters to form a collection of local perceptions (Table 1).   Before each interview, the participant was shown a series of photos of different mustelid species to determine the reliability of their responses. An incorrect photo identification of a river otter disqualified the participant's responses. Reliable participants were encouraged to provide testimony of their otter encounters. Participants were presented with a Google satellite representation of the study area in QGIS, where people could zoom in and out to locate landmarks and drop points in the locations where they identified encounters with the species or their tracks. . The participants used the points to create a map that visually represented the traditional local knowledge about Neotropical river otters. In the absence of reliable field data, both the species presence and quality of habitat was inferred from the survey data. The interview data was supplemented with field observations collected during the dry season. In an attempt to locate river otters, or

Table 1: Questionnaire used to Guide the Interviews

1	Have you seen any river otters or their tracks (footprints or scat) in the Rio Penas Blancas or Penitas Blancas in the last 3 months? **If yes continue to question 2, if no skip to question 4.**
2	Can you point out the location(s) at which you have seen river otters in the last 3 months on this map?
3	Can you point out locations at which you remember seeing otter footprints or scat in the last 3 months on this map?
4	Have you ever seen a river otter in the Rio Penas Blancas or Penitas Blancas? When? Can you point out the locations on this map and tell me roughly the date of each encounter? **If yes, continue to question 5, if no skip to question 11.**
5	Can you point out any areas on the map where you feel there are higher chances of encountering river otter along the Rio Penas Blancas?
6	How frequently have you encountered river otters in the past 5 years? How big were they? What time of year was it? Do you see them alone or in a group?
7	How frequently have you encountered traces of river otter in the past 5 years? (scat, footprints, den, other)
8	Have you seen more or less otters in the past 5 years?
9	Do you encounter river otter more frequently in faster running water or slower?
10	Do you encounter river otter more frequently in shallow water or in deep water?
11	Has there been an increase or a decrease in the number of fish in the Rio Penas Blancas or Penitas Blancas in the last 5 years? Can you point out areas where there is the highest number of fish on this map?
12	Has there been an increase or a decrease in the number of mulluscs and crustaceans in the Rio Penas Blancas or Penitas Blancas in the last 5 years? Can you point out areas with the highest number of crustaceans on this map?
13	According to you, are the Rio Penas Blancas and Penitas Blancas in good health?
14	According to you, are the Rio Penas Blancas and Penitas Blancas at risk of destruction due to human impacts?

Table 1: Questionnaire used to guide the interviews with local fishermen. Due to low literacy amongst this sample, the questions were read aloud. A conversation was then encouraged for each question to encourage participants to elaborate and animate their experiences with Neotropical river otters. The interviews were conducted at the interviewee's home, in Spanish.

any signs of them, an assistant from the community of Santa Elena guided a walking field survey of both Rio Peñas Blancas and Peñas Blanquitas from Las Nubes to Los Cusingos, a total of approximately 10.7km (see Table 2). When signs of suspected otter activity were encountered a photograph was taken and a GPS coordinate was recorded. Field survey maps and interviewee maps were compiled and compared (Gilchrist et al. 2005).

Table 2: Field Survey Schedule

Date	Time	Location
Feb. 17, 2016	9:00-11:00	-83.62754, 9.34011 to -83.62543, 9.33640
Feb. 18, 2016	9:00-11:00	-83.62543, 9.33640 to -83.62537, 9.33960
Feb. 19, 2016	9:00-11:00	-83.62537, 9.33960 to -83.62395, 9.34518
Feb. 23, 2016	8:30-11:00	-83.62395, 9.34518 to -83.61807, 9.35025
Feb. 25, 2016	8:00-10:00	-83.61807, 9.35025 to -83.61399, 9.5324
Mar. 1, 2016	9:00-11:00	-83.61238, 9.35716 to -83.61399, 9.5324
Mar. 2, 2016	9:00-11:00	-83.62543, 9.33640 to -83.62344, 9.33305

Mar. 3, 2016	9:00-11:00	-83.59858, 9.38871 to -83.60145, 9.382673
Mar. 7, 2016	7:00-9:30	-83.60816, 9.36205 to -83.61238, 9.35716
Mar. 8, 2016	8:00-10:00	-83.60816, 9.36205 to -83.60639, 9.37519
Mar. 9, 2016	8:00-10:00	-83.60848, 9.35739 to -83.61238, 9.35716
Mar. 10, 2016	7:00-9:30	-83.60145, 9.382673 to -83.60816, 9.36205
Mar. 11, 2016	7:00-10:30	-83.59128, 9.36769 to -83.60848, 9.35739
Mar.14, 2016	8:00-10:00	-83.62513, 9.32761 to -83.62344, 9.33305

Table 2: The date, time, and locations of field sampling efforts are presented in this table.

Results

I interviewed 25 men; the skewed sex distribution was presumably due to cultural differences in labor in distribution. In the last five years, 86% of survey participants reported encountering Neotropical river otters, but only 18% had seen otters in the previous three months (Figure 2). Of those who hadn't observed any otters, 50% were marine fishermen and explained that they spent little or no time near the rivers Peñas Blancas and Peñas Blanquitas. Very few otters were observed in interviewees' lifetime and although 43% of the locals believe that there are fewer river otter now than five years ago, the results of this survey question were inconclusive as 24% of respondents admitted they did not know and another 24% believed that their numbers hadn't changed. Interviewees suggest otter numbers fluctuate with wet and dry season; with increases during the rainy season with increased fish abundance. Otter observations were either of a solitary adult or an adult with babies (sighted more frequently during the rainy season). When asked about whether they had seen any signs of river otter activity 64% of respondents had encountered scat (Figure 2). Participants were asked to point out areas on the map where there is the best chance of encountering an otter, and 100% identified south of the study area, in Los Cusingos and below. In addition to the southwestern region of ASBC, 30% of participants also identified the mountains, from Las Nubes to Chirripó National Park as preferred habitat for the Neotropical river otter.

A

B

C

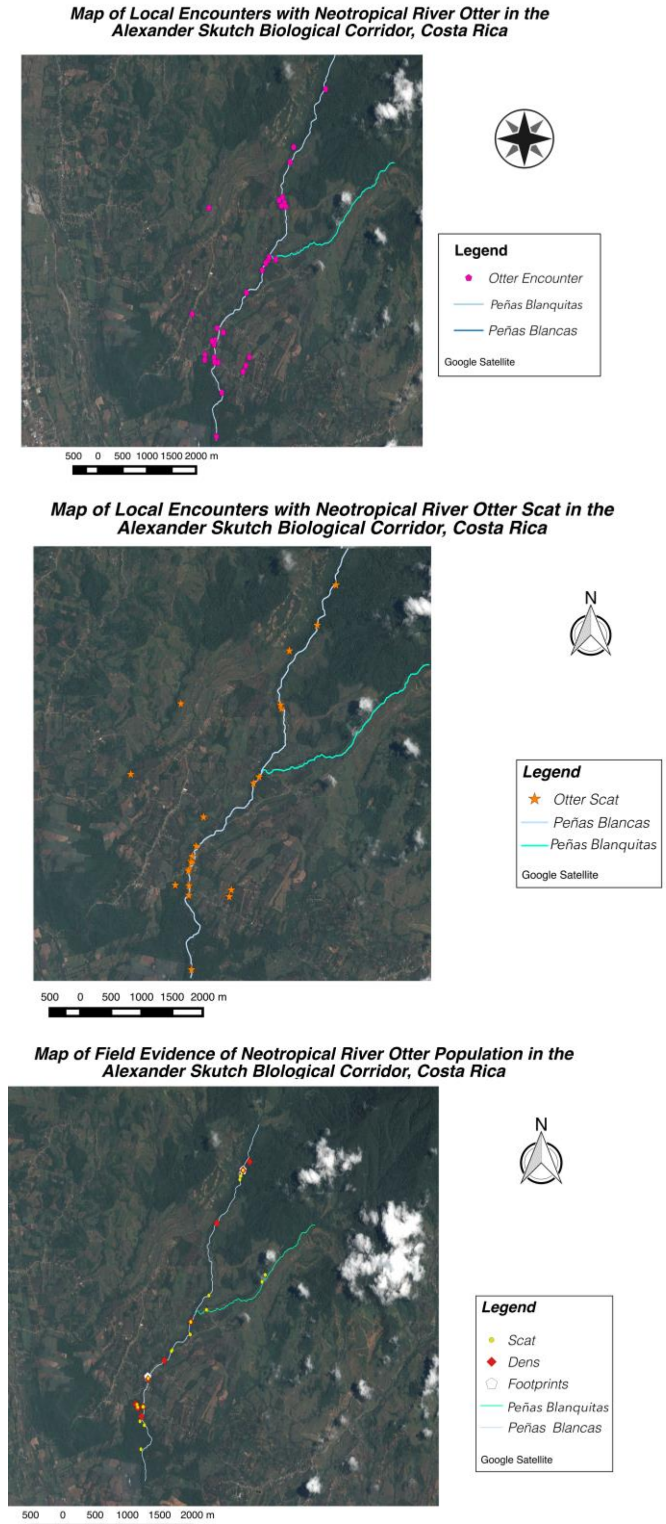

Figure 2: a) A map of otter encounters created by interview participants. b) A map of encounters with otter scat created by interview participants. c) A map of otter scat, dens, and footprints found during the field surveys. The maps were made in QGIS on a Google Satellite base map. The first two maps were created by interview participants who were able to manipulate the map in search of landmarks and place points in locations where they had observed *L. longicaudis* signs or the animal.

Of participants, 90% think there has been a decline in fish and crustacean populations over the last five years despite that they thought Rio Peñas Blancas and Rio Peñas Blanquitas were healthy. Locals fear for the future of the rivers as 72% of participants believe that they are in danger of destruction due to human interferences; from that group, 70% named hydroelectric projects as the leading threat to the rivers.

A total of 21 scats, 11 dens, and 2 sets of footprints were discovered at different locations during the study period (Figure 2). Only three otter scat were found in the smaller river Peñas Blanquitas.

There are a few points that interview participants placed outside of the rivers of interest: the ones in the west of Peñas Blancas are located along Rio Hermosa, and the ones east of Peñas Blancas are along Rio Calientillo. These rivers are not threatened by plans for hydroelectric projects and were not subject to field surveys. A few people had seen otter on their property, especially those who have tilapia ponds and found that the otter had come to hunt. There are some negative feelings towards the otter for this reason, and a few locals admitted to setting traps to capture them or knew someone who had. The lack of encounters in Rio Peñas Blanquitas may be due to the fact that it passes far behind the community of Montecarlo, through pastures owned by only a handful of people, however this lack of encounters is consistent with the field survey data depicted in Figure 2c.

The map in Figure 3 combined both interview and field data into a hotspot map of Neotropical river otter activity in ASBC. The data is concentrated along Rio Peñas

Blancas, with few points on Rio Peñas Blanquitas. The highest number of points located within 300m^2 is eleven. This is located at the northern border of Los Cusingos and is surrounded by a number of other hotspots. This result agrees with the survey responses to the question of where the best chances of encountering otters are located. There is another large hotspot located just south of where the two rivers join. Here the river passes through a multitude of properties with denser vegetation surrounding the river's sides. Based on both the ecological characteristics of the northern mountainous zone of the study area and the results of the surveys, it was expected that there would be a concentration of hotspots from Las Nubes northward however, there is very little activity discovered there during this study.

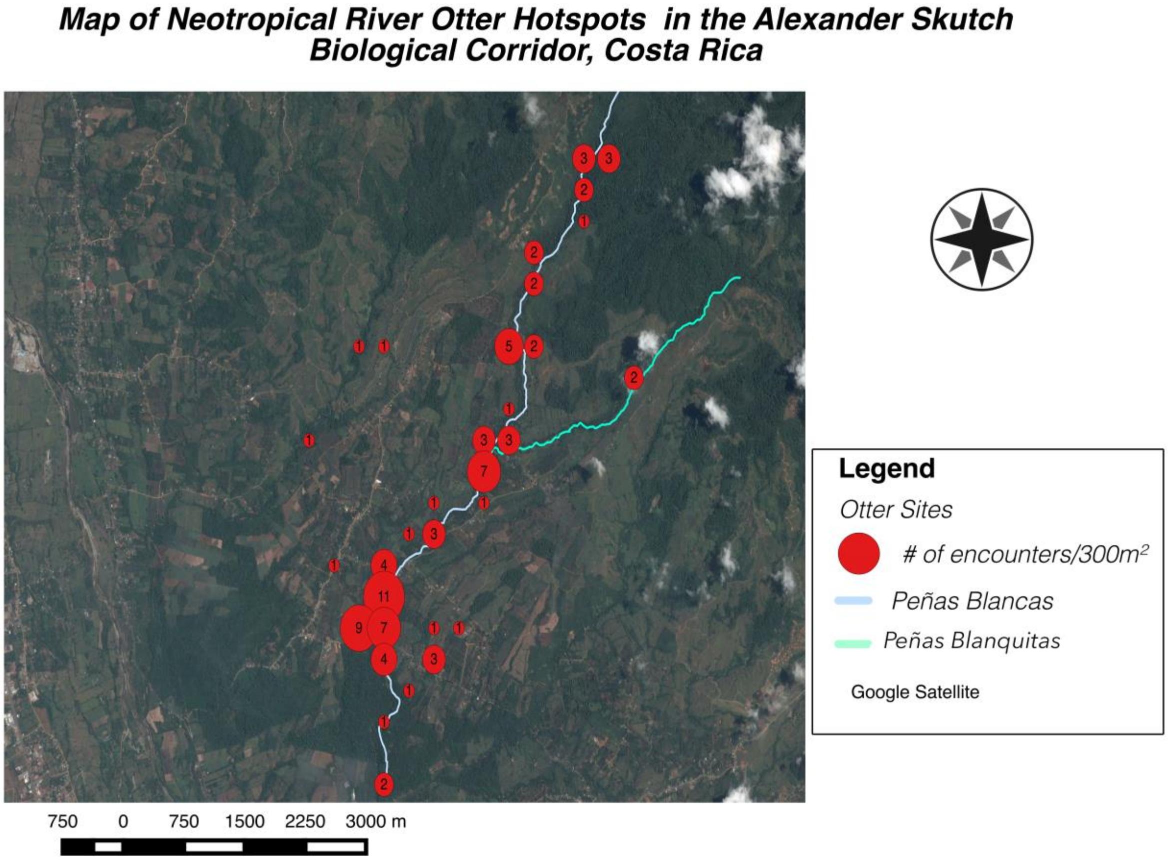

Figure 3: A hotspot map of Neotropical river otter activity in ASBC. This map combines the data from Figure 2. In QGIS a 300m x 300m grid was placed over the map of the study area and the sum of all points within each $300m^2$ box is displayed inside the red circles on the map. The circles were then sized according to the number of points they contain to enhance visual comprehension.

Discussion

The majority of the locals interviewed provided observations of river otter or river otter scat and appeared knowledgeable about otter habits. Fishermen were preferred survey participants because bias would have been introduced with a random sampling method due to the nature of the species of interest. Inferring from Eurasian river otter (*Lutra lutra*), who only travel a maximum of 100m from the shoreline (Krukk and Moorhouse 1991), it is likely impossible for those who don't frequent the river to encounter Neotropical river otters. The majority of participants had seen an otter, which signifies that a population exists in ASBC. Based on the responses it is likely that there is a low number of otters using the rivers: the maximum number of encounters with river otters in their lifetime reported by participants was five. .

The interviewees expressed concern about the state of the rivers. The fish and crustacean populations in the rivers have been depleted and locals believe it is due to overfishing. The rivers are perceived to be extremely clean, which locals take as a sign of good health, yet the majority fear that they are in danger of destruction due to human interventions. The greatest perceived threat to the rivers is of hydroelectric project proposals that would dry out the rivers completely. Deforestation and pollution were second to the threat of a hydroelectric dam, but the majority proudly stated that the communities in ASBC are environmentally responsible and treat their resources sustainably. This positive attitude towards conservation, coupled with the existence of appropriate technical and monetary incentives (Lamb et al. 2005), indicates that the corridor communities are of value to participatory community conservation projects (Sheil and Lawrence 2004).

During the field surveys scats were identified visually given the unique visual characteristics of otter scat and the presence of fish scales (Greer 1955, Mason and Macdonald 1986), although Davison et al. (2002) suggests that genetic analysis is preferred to morphological identification. Footprints were also identified visually. Only the front paw prints were found during the study because of the infrequency of occurrence of appropriate mediums to deposit them in. Very few scats were found along Rio Peñas Blanquitas, but their presence indicates that the otter are using the river, however infrequently. In comparison to Peñas Blancas, Peñas Blanquitas has both little overhanging vegetation and many more areas with completely open canopy. Otters show preference for dense vegetation and exposed roots (Casariego-Madorell et al. 2006), which explains why they prefer Peñas Blancas. Although the surveys did not produce a visual encounter with river otters the presence of both their scat and fish scales found on rocks is evidence of the species' presence in ASBC.

Both the interview data and the field survey results agree that Neotropical river otter are present in both Rio Peñas Blancas and Rio Peñas Blanquitas. All of the maps in Figure 2 show aggregations of points in the same locations contributing to the hotspots of otter activity in Figure 3. The interview results for locating otter hotspots was accurate in pointing out the largest hotspot (see Figure 3) although field data did not confirm the presence of a second significant hotspot in Las Nubes. Some locals speculated that the water in the mountains might be too cold and so instead the otter preferred the southern region. Water temperatures were not taken for comparison, and there is no validation for this theory in the literature, as this species has been found at higher elevations by previous researchers (Gomez et al. 2014, Shipper et al. 2008, Pacheco et al. 2006, Henderson 2010). Despite some inconsistencies, similarities in the two datasets gives strength to the argument that the locals in ASBC hold reliable, traditionally acquired knowledge that is valuable to biodiversity conservation.

There was a great lack of field data due to time constraints, difficulties with travel, and a small research team that allowed each site to be visited only once. This method was not effective because of both the large range that the otters occupy and their propensity to travel daily (Melquist and Hornocker 1983, Krukk and Moorhouse 1991).

The study could be improved by having a larger team so that the study area could be divided and pairs of researchers can visit the same site repeatedly. More people in different areas at the same time would increase the chances of encountering an otter of their tracks. The lack of direct observation during the study may also have been caused by a seasonal decrease in population size. Although Neotropical river otter have extremely flexible diets (Pardini 1998, Ker de Andrade 1997), the fish population was so low during the study period that it may be possible that the otters relocated during the dry period in search of prey. Supplementing the field surveys with local knowledge derived from interviews allowed the study of a longer time period, which revealed that the population of Neotropical river otters in the study area has been small for at least the last five years.

The maps presented in this paper can be used by locals in ASBC to argue for increased water rights because they are evidence that a rare species exists in their watershed. River otters are completely dependent on riverine habitats for prey availability (Mason and Macdonald 1986) and their populations can be used to infer the health of river systems (Kannan et al. 2002, Kelly and Whitton 1995) and to predict population dynamics across trophic levels because they are top of the food chain (Roemer et al 2009), which makes them excellent indicator species for river habitat quality. The interview data reveal the level of concern that locals have for their water resources and attention they pay to predators that share their ecosystem. Locals may therefore use these results to solicit support and funding from the Costa Rican or other government organizations and/or national or trans-national non-governmental organizations that are interested in the conservation of ASBC.

Conclusion

The local communities of the Alexander Skutch Biological Corridor are extremely environmentally aware. Due to both a partnership with York University that encourages community engagement (Daugherty 2005) and the high volume of students and professors conducting research and field courses in the area, and because of the initiative that the locals took to defend their rivers from destructive hydroelectric projects (Monge, personal communication, 2016), local community members have become more sensitive to the effects of both habitat degradation and unsustainable resource management. The information provided by the interview participants both provides geographic data that can be used to guide future investigations and highlights their ability and eagerness to participate in resource management initiatives, if the proper capacities were developed within the community. The interviews and field data provide support for the premise that Neotropical river otters inhabit the rivers Peñas Blancas and Peñas Blanquitas. Any hydroelectric project built on these rivers will destroy the habitat required to support these organisms, which indicates the demise of a number of other species that also rely on the same ecosystem. Involving locals in discussions about their resources and providing them with benefits in return for environmental protection instills a sense of responsibility and promotes the maintenance of a clean and healthy ecosystem (Mehta and Heinen 2001).

References

Brosius, J. P., Tsing, A. L., & Zerner, C. (1998). Representing communities: Histories and politics of community-based natural resource management.

Bryce, C. (2011) Optimal Survey Methods for Elusive Mammals in a Costa Rican Tropical Cloud Forest. Point Loma.edu

Campbell, L. M., & Vainio-Mattila, A. (2003). Participatory development and community-based conservation: Opportunities missed for lessons learned?. Human Ecology, 31(3), 417-437.

Carrillo-Rubio, E., & Lafón, A. (2004). Neotropical River Otter Micro-Habitat Preference In West-Central Chihuahua, Mexico. IUCN Otter Spec. Group Bull,21(1), 10-15.

Casariego-Madorell, M. A., Sánchez, R. L., & González, G. C. (2006). Aspectos básicos sobre la ecología de la nutria de río (Lontra longicaudis annectens) para la costa de Oaxaca. Revista Mexicana De Mastozoologia. (Nueva Época), 10(1), 71-74.

Chemes, S. B., Giraudo, A. R., & Gil, G. (2010). Dieta de Lontra longicaudis (Carnivora, Mustelidae) en el Parque Nacional El Rey (Salta, Argentina) y su comparación con otras poblaciones de la cuenca del Paraná. Mastozoología neotropical, 17(1), 19-29.

Colchester, M. (2005)1. "Maps, power, and the defense of territory: the Upper Mazaruni land claim in Guyana." Communities and conservation: Histories and politics of community-based natural resource management (2005): 271-304.

Daily, G. C., Ceballos, G., Pacheco, J., Suzán, G., & Sanchez-Azofeifa. (2003). Countryside biogeography of neotropical mammals: conservation opportunities in agricultural landscapes of Costa Rica. Conservation biology, 17(6), 1814-1826.

Daugherty, H. E. (2005). Biodiversity conservation and rural sustainability: a case study of the Alexander Skutch Biological Corridor in Southern Costa Rica. WIT Transactions on Ecology and the Environment, 81.

Davison, A., Birks, J. D., Brookes, R. C., Braithwaite, T. C., & Messenger, J. E. (2002). On the origin of faeces: morphological versus molecular methods for surveying rare carnivores from their scats. Journal of Zoology, 257(2), 141-143.

Gallo, J. P. (1996). Distribution of the Neotropical river otter (Lutra longicaudis annectens Major, 1897) in the Rio Yaqui, Sonora, México. IUCN otter speciallist Group Bulletin, 13, 27-31.

Gilchrist, G., Mallory, M., & Merkel, F. (2005). Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. Ecology and Society, 10(1), 20.

Gomez, J. J., Túnez, J. I., Fracassi, N., & Cassini, M. H. (2014). Habitat suitability and anthropogenic correlates of Neotropical river otter (Lontra longicaudis) distribution. Journal of Mammalogy, 95(4), 824-833.

Greer, K. R. (1955). Yearly food habits of the river otter in the Thompson Lakes region, northwestern Montana, as indicated by scat analyses. American Midland Naturalist, 299-313.

Henderson, C. L. (2010). Mammals, amphibians, and reptiles of Costa Rica: a field guide (Vol. 66). University of Texas Press.

Kannan, K., Newsted, J., Halbrook, R. S., & Giesy, J. P. (2002). Perfluorooctanesulfonate and related fluorinated hydrocarbons in mink and river otters from the United States. Environmental science & technology, 36(12), 2566-2571.

Kelly, M. G., & Whitton, B. A. (1995). The trophic diatom index: a new index for monitoring eutrophication in rivers. Journal of Applied Phycology, 7(4), 433-444.

Ker De Andrade, H. (1997). Food and feeding habits of the neotropical river otter Lontra longicaudis (Carnivora, Mustelidae). Mammalia, 61(2), 193-204.

Kruuk, H. (2006). Otters: ecology, behaviour and conservation. Oxford University Press.

Kruuk, H., & Moorhouse, A. (1991). The spatial organization of otters (Lutra lutra) in Shetland. Journal of Zoology, 224(1), 41-57.

Lamb, D., Erskine, P. D., & Parrotta, J. A. (2005). Restoration of degraded tropical forest landscapes. Science, 310(5754), 1628-1632.

Leach, M., Mearns, R., & Scoones, I. (1999). Environmental entitlements: dynamics and institutions in community-based natural resource management. World development, 27(2), 225-247.

Malmqvist, B., & Rundle, S. (2002). Threats to the running water ecosystems of the world. Environmental conservation, 29(02), 134-153.

Martínez, Ana María & Saker, Chris. (2012). Las Nubes: Conservation in the Cloud Forests of Costa Rica. Rainforest Editions. York University Bookstore.

Mason, C. F., & Macdonald, S. M. (1986). Otters: ecology and conservation. Cambridge University Press.

Medina-Vogel, G., Kaufman, V. S., Monsalve, R., & Gomez, V. (2003). The influence of riparian vegetation, woody debris, stream morphology and human activity on the use of rivers by southern river otters in Lontra provocax in Chile.Oryx, 37(04), 422-430

Mehta, J. N., & Heinen, J. T. (2001). Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. Environmental management, 28(2), 165-177.

Melquist, W. E., & Hornocker, M. G. (1983). Ecology of river otters in west central Idaho. Wildlife monographs, 3-60.

Monge, L. Personal communication. February 10, 2016.

Montoya-Greenheck, F. Personal communication. July, 2016

Mooring, M., Bryce, C., Dahl, R., Fares, A., & Stull, T. (2011) Savegre Valley Mammal Study–Progress Report. Point Loma.edu.

Mooring, M., Poorboy, D., Fowler, J., Asselin, E., Butera, S. Talamanca Large Mammal Study – Progress Report 2015. PointLoma.edu

Noy, C. (2008). Sampling knowledge: The hermeneutics of snowball sampling in qualitative research. International Journal of social research methodology, 11(4), 327-344.

Oviedo, G., Gonzales A., and Maffi, L. (2004). The Importance of Traditional Ecological Knowledge and Ways to Protect It. Protecting and promoting traditional knowledge: systems, national experiences and international dimensions. UN.

Pacheco, J., Ceballos, G., Daily, G. C., Ehrlich, P. R., Suzán, G., Rodríguez-Herrera, B., & Marcé, E. (2014). Diversidad, historia natural y conservación de los mamíferos de San Vito de Coto Brus, Costa Rica. International Journal of Tropical Biology and Conservation, 54(1), 219-240.

Pardini, R. (1998). Feeding ecology of the neotropical river otter Lontra longicaudis in an Atlantic Forest stream, south-eastern Brazil. Journal of Zoology, 245(4), 385-391.

Pardini, R., & Trajano, E. (1999). Use of shelters by the neotropical river otter (Lontra longicaudis) in an Atlantic forest stream, southeastern Brazil. Journal of Mammalogy, 80(2), 600-610.

Prowse, T. D., Beltaos, S., Gardner, J. T., Gibson, J. J., Granger, R. J., Leconte, R., ... & Toth, B. (2006). Climate change, flow regulation and land-use effects on the hydrology of the Peace-Athabasca-Slave system; Findings from the Northern Rivers Ecosystem Initiative. Environmental Monitoring and Assessment, 113(1-3), 167-197.

Quadros, J., & Monteiro-Filho, E. L. A. (2002). Sprainting sites of the Neotropical otter, Lontra longicaudis, in an Atlantic Forest area of southern Brazil. Mastozoología neotropical, 9(1), 39-46.

Rheingantz, M.L., Trinca, C.S. (2015). Lontra longicaudis. The IUCN Red List of Threatened Species 2015. www.iucnredlist.org. Downloaded on July 16, 2016.

Ritchie, J., Lewis, J., Nicholls, C. M., & Ormston, R. (Eds.). (2013). Qualitative research practice: A guide for social science students and researchers. Sage.

Roemer, G. W., Gompper, M. E., & Van Valkenburgh, B. (2009). The ecological role of the mammalian mesocarnivore. BioScience, 59(2), 165-173.

Sheil, D., & Lawrence, A. (2004). Tropical biologists, local people and conservation: new opportunities for collaboration. Trends in Ecology & Evolution, 19(12), 634-638.

Shipper, J., Hoffman, M., Duckworth, J. W., & Conroy, J. (2008). The 2008 IUCN red listings of the world's small carnivores. Small Carnivore Conservation, 39, 29-34.

Wells, M. P., & Brandon, K. E. (1993). The principles and practice of buffer zones and local participation in biodiversity conservation. Los principios y la práctica de las zonas de amortiguamiento y la participación local en la conservación de la biodiversidad. Ambio., 22(2/3), 157-162.

Challenges in detecting Neotropical river otters in a biological corridor in southwestern Costa Rica using camera traps

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Abstract

This study evaluated the efficacy of camera-traps to investigate the presence or absence of rare Neotropical river otter (*Lontra longicaudis*) in the adjoining rivers Peñas Blancas and Peñas Blancitas in the Alexander Skutch Biological Corridor in southwestern Costa Rica. Initially five Cuddeback Capture cameras were deployed at regular intervals, in locations informed by a local community member, then the cameras were moved to increase sampled areas. After the loss of two cameras two Bushnell Nature View Essential cameras were deployed as replacements. The study effort was insufficient for concluding absence of the otters and the presence of a population was not corroborated by camera-trap data.

Este estudio evaluó la eficacia de las cámaras-trampa para investigar la presencia o ausencia de una rara nutria neotropical (*Lontra longicaudis*) en los ríos contiguos Peñas Blancas y Peñas Blancitas en el Corredor Biológico Alexander Skutch en el suroeste de Costa Rica. Inicialmente cinco cámaras Cuddeback Capture se desplegaron a intervalos regulares, en lugares informados por un miembro de la comunidad local, a continuación, las cámaras fueron trasladados para aumentar las áreas muestreadas. Después de la pérdida de dos cámaras, dos cámaras Bushnell Nature View Essential fueron desplegados como reemplazos. El esfuerzo estudio fue insuficiente para concluir la ausencia de la nutria y la presencia de una población no se corroboró por los datos de la cámara-trampa.

Introduction

For the success of any resource management or species conservation program it is important to first establish a working baseline of population abundance and distribution. Traditionally, mark-recapture projects were carried out to collect species demographic data; however this method is time consuming, costly, and may hurt or stress the animals (Carbone et al. 2002). Camera traps are increasingly used to study both spatial and temporal distributions of species because they allow researchers to remotely observe animals in the field (Long et al. 2012). Camera traps are especially useful for behavioral studies because they diminish bias related to the presence of humans (Van Schaik and Griffiths 1996), although Cutler and Swann (1999) highlight that human scent or the cameras themselves may attract or deter animals from the site. Schipper (2007) also found that the flash of certain camera models negatively affects the behavior of mammals that rely heavily on visual cues, resulting in stress and camera-trap avoidance. Nonetheless, camera traps both eliminate the need to handle animals and facilitate increased spatial and temporal scales (Kelly and Holub 2008).

Camera traps are used to study a number of species demographic variables, from simple presence/absence (Farhadinia 2004) to more complex population parameters (Mace et al. 1994, Koerth et al. 1997, Karanth 1995). Occupancy analysis from camera surveys is used to produce a species-specific capture probability that, in turn, is used to confidently calculate abundances (Kelly and Holub 2008). Camera trap occurrence data are also useful for predicting habitat preferences and prey availability (Zielinski et al. 2005, Linkie et al. 2006). To increase the likelihood of capturing elusive species researchers use bait or scent markers, or selectively place the cameras in locations preferred by the species of interest (Rowcliffe and Carbone 2008).

Unfortunately the usefulness of camera traps for most animals is limited due to the inability to visually differentiate between individuals of the same species, although according to study by Lyra-Jorge et al. (2008) camera traps provided more accurate identifications in comparison to track identification. For species where individuals have distinct markings, such as tigers and other species of felines, there is less of an issue and therefore camera traps can be used to perform accurate capture-recapture models without the need to disturb the animals (Kelly and Holub 2008).

In this study I determined the efficacy of camera traps to investigate the presence or absence of rare Neotropical river otter (*Lontra longicaudis*) in the adjoining rivers Peñas Blancas and Peñas Blancitas in the Alexander Skutch Biological Corridor in southwestern Costa Rica.

Methods

Study Area

Alexander Skutch Biological Corridor in southwestern Costa Rica consists of various habitat types and forest patches of assorted ages (Fig 1; Daugherty 2005). The majority of the rivers exist on privately owned, agricultural or residential properties. The rivers are in close proximity to human activity that includes livestock and pets. The habitat on these rivers consist of a small buffer of secondary tropical rainforest that abruptly shifts to other land-use types such as pasture or residential in areas south of the Las Nubes reserve. The corridor as a whole has had a reported 19% deforestation rate from 1998-2008 (Rapson et al. 2012) although at higher elevations in the Las Nubes Reserve the forest was a mix of primary and secondary growth (Martinez and Saker 2012). The forest becomes pristine primary tropical cloud forest as it approaches Chirripó National Park, where the two rivers originate. In the southern section of the study area there is an island of primary forest surrounded by privately owned farms and residences called Los Cusingos Tropical Reserve (Fig 1). Both rivers have tributary streams where the currents are weaker, many of which were dry during the study period. The total study area was $53km^2$ although the study took place only along the rivers.

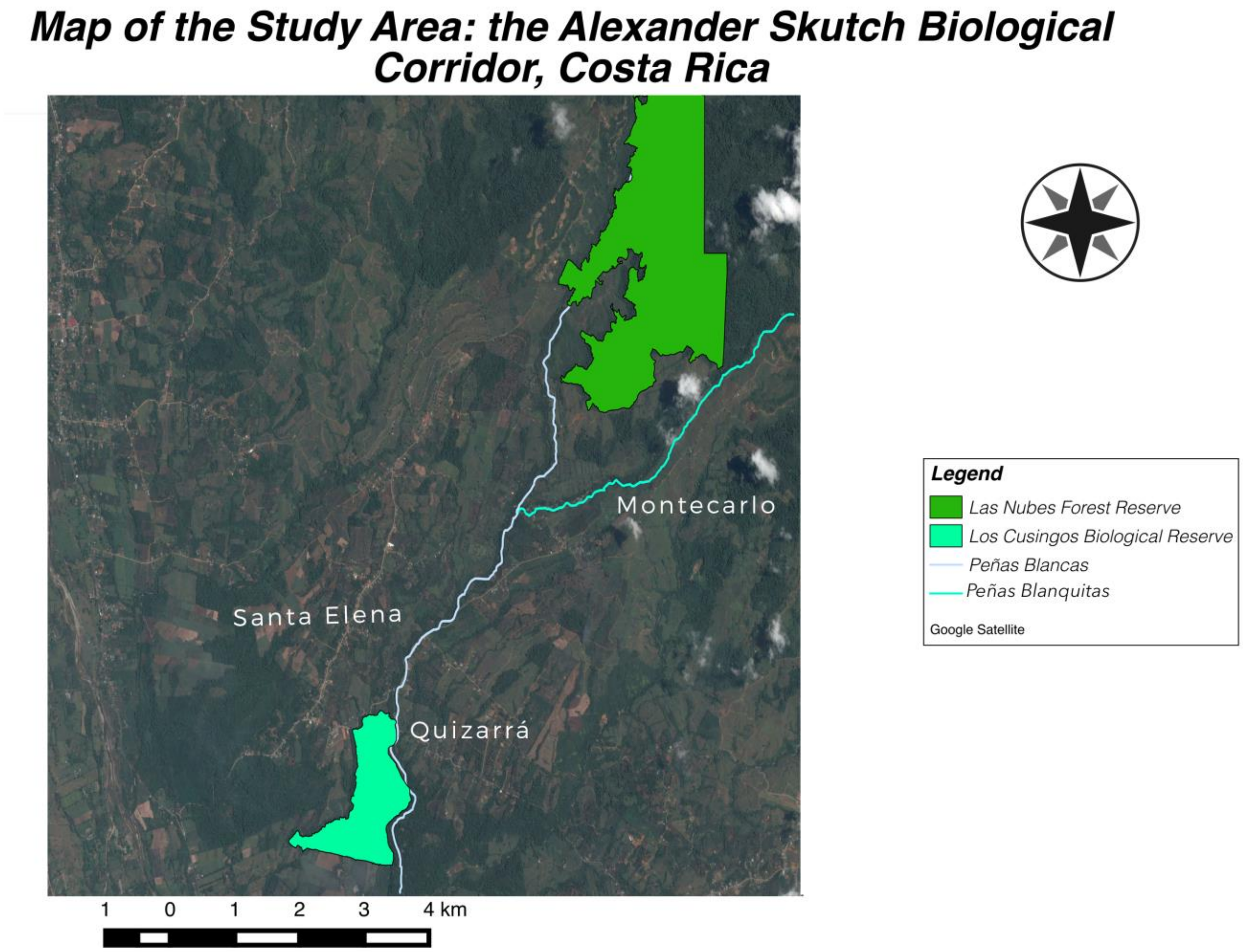

Figure 1: A map of the Alexander Skutch Biological Corridor displaying both the rivers Peñas Blancas and Peñas Blanquitas, and the two forest reserves; Los Cusingos Tropical Bird Sanctuary and Las Nubes Tropical Forest Reserve.

Seven camera traps (five Cuddeback Capture IRs and two Bushnell Nature View Essentials) were deployed from February 5 – March 18, 2016. All cameras used passive infrared sensors and infrared flash. The Cuddeback cameras were set to a 30s interval between triggering and trigger speed was 0.33s. The Bushnell cameras were set to a trigger interval of 1s and had a trigger speed of 0.6s. The Bushnell cameras were also set to capture bursts of three images per trigger. The five Cuddeback cameras were deployed in the first week and the two Bushnell cameras were deployed to replace two cameras that either broke or were stolen. Cameras were strategically placed to capture different habitat type in different locations along the rivers using maps and interviews with local community members (See Table 1 and Figure 2). Cameras were redeployed to different locations approximately biweekly to increase spatial coverage. The memory cards were changed every week to collect photos. All mammals captured on the camera were recorded.

Map of Camera-Trap Deployment Locations in the Alexander Skutch Biological Corridor, Costa Rica

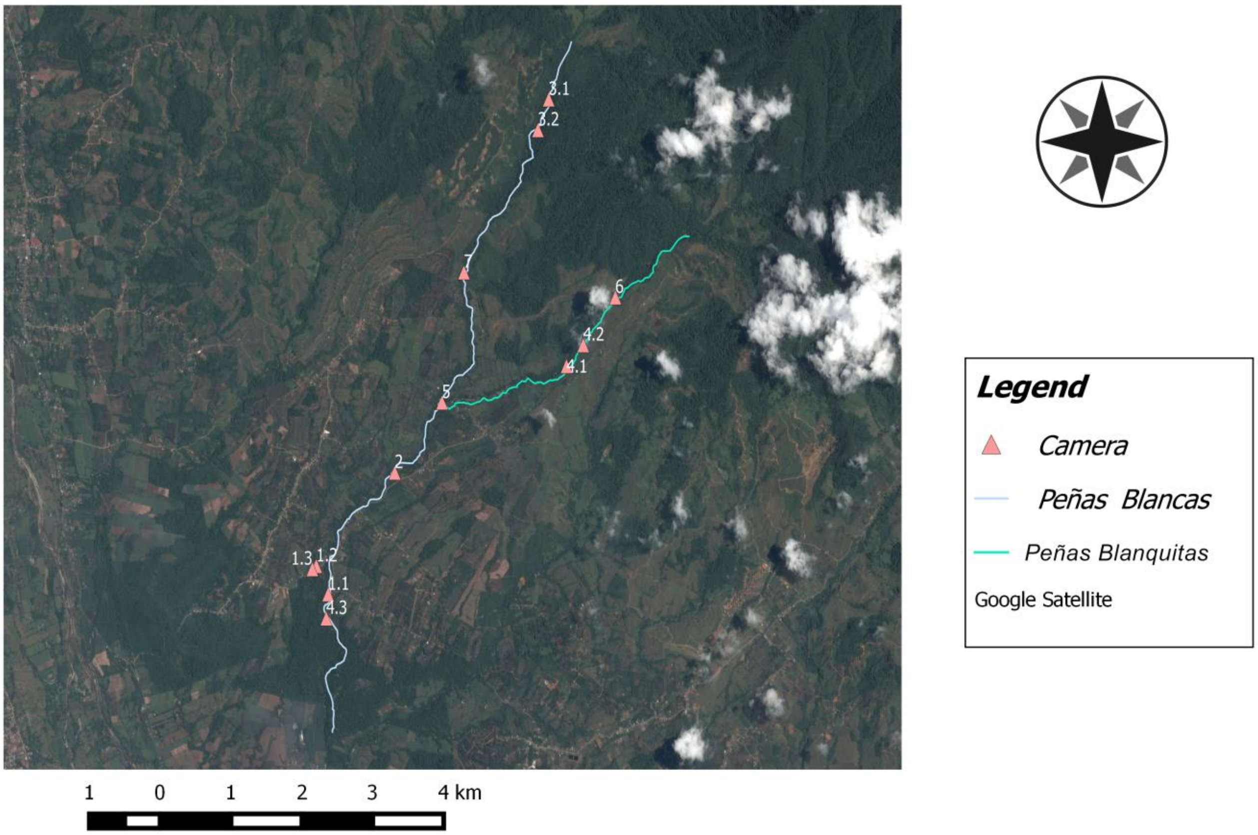

Figure 2: A map of the study area with aggregated camera placements. The cameras that had been moved are labelled with decimals denoting its position in the series. All of the cameras are located along the rivers except Camera 1.2 and 1.3 that are place in a residential backyard with a tilapia pool and along a tributary stream respectively.

Table 1: Camera-trap Deployment Schedule

Camera	Location	Dates Deployed	Habitat Type	Motivation for Selection
1.1 Cuddeback	Residential lowland -83.6255, 9.3386	February 5-March 1, 2016	Private Property. Strip of forest bordering Los Cusingos and the road.	Location selected by local because of a previous otter sighting.
1.2 Cuddeback	Residential lowland -83.6269, 9.3414	March 1-March7, 2016	Private Property. Backyard with Tilapia Pool.	Location selected because owner claimed otter have eaten their tilapia.
1.3 Cuddeback	Residential lowland -83.6274, 9.3411	March 7-March 16, 2016	Tributary between two residences. Small forest patch.	Location selected because locals report seeing otters in this tributary.
2 Cuddeback	Residential lowland -83.6179, 9.3499	February 5-February 29, 2016 (last camera day Feb. 11)	Private property with surrounding secondary forest.	Location selected by local because of reforestation.
3.1 Cuddeback	Las Nubes mountains -83.5992, 9.3871	February 6-March 3, 2016	Primary forest reserve. Distant from roads but close to trails.	Location selected by local for water pool.
3.2 Cuddeback	Las Nubes mountains -83.6005, 9.3841	March 3-March 18, 2016	Primary forest reserve. Distant from roads but close to trails.	Location selected because of a large pool close to a trail.
4.1	Residential mountains	February 6-February 22,	Private property.	Location selected by

Cuddeback	-83.5971, 9.3610	2016	Secondary forest near pasture.	local for water pool.
4.2 Cuddeback	Residential mountains 83.5951, 9.3630	February 22-March 2, 2016	Private property. Secondary forest near pasture.	Location selected by local for water pool.
4.3 Cuddeback	Los Cusingos lowlands -83.6257, 9.3363	March 3-March 16 (broken through period)	Private forest reserve. Primary forest close to trails with no roads.	Location selected because it is inside a protected area.
5 Cuddeback	Residential lowlands -83.6119, 9.3574	February 6-unknown (stolen)	Private property where two rivers join. Secondary forest close to trails.	Location selected by local for water pool.
6 Bushnell	Residential mountains -83.5912, 9.3677	March 4-March 8, 2016 (batteries died)	Private property. Secondary forest at the end of a trail.	Location selected by local for water pool.
7 Bushnell	Residential mid-elevation -83.6093, 9.3225	March 8-March 18	Private property in close proximity to pasture. Thin secondary forest strip between pasture and river.	Location selected facing a path that exited the river area.

Table 1: Camera number and type are displayed here in column one, next their GPS coordinate (WGS 84) and location description in column two. Camera numbers with decimals represent the same camera in different location. The dates deployed represent the time interval that the cameras were in the field in the specific location. The final two columns describe the habitat of the specific location and the motivation behind its selection.

Camera trap data were analyzed to determine Neotropical river otter presence/absence and occupancy relative to other mammal species whose photographs are captured by the cameras. Other mustelid species such as tayra and weasels are of special interest as they are often confused for river otter. Unadjusted occupancy estimates will be calculated by dividing the number of sites at which an animal is captured by the total number of sites (Baldwin and Bender 2008). Occupancies that account for detectability of each species will be modeled according to an algorithm developed by Mackenzie et al. (2005). Relative abundance of each species will be calculated as follows:

(# occurrences of species x / total # of occurrences of all species) X 100

Occurrences are defined as photos of an individual taken at both a specific time and location. If multiple photos of an individual occur in the same location, within five minutes of each other, they are considered the same occurrence. If animals travel in groups then the largest number of individuals distinguishable in a single picture is the number of individuals for that occurrence (Liu et al. 2013). This study will also look for differences in both river otter abundance and habitat quality.

Results

Table 2: Summary of Results Obtained from the Camera-Trap Survey of the Peñas Blancas River System

Camera	Number of Camera Days	Number of Mammal Images Captured
1.1	25	1
1.2	7	0
1.3	9	0
2	6	1
3.1	26	1
3.2	15	0
4.1	16	0
4.2	9	0
4.3	0	0
5	0	0
6	0	0
7	10	3

Table 2: The results of this study are summarized in this table. The number of functioning camera days for each camera are shown in the second column. The first placement of Camera 1 yielded one photo of an opossum. Camera 2 yielded a one photo of a tayra. The first placement of Camera 3 yielded one photo of a grisson. Lastly, Camera 7 captured three mammalian species; a coyote, a few bursts of photos of a coati (same occurrence), and couple photos of a tayra (same occurrence).

The cameras captured a total of five mammalian species during this study: opossum, tayra, grisson, coyote, and coati. The tayra was captured by both Camera 2 and Camera 7 however this species lacks individually identifiable markings, the size difference was insignificant, and the cameras were located within the same range, therefore it is impossible to determine whether they are different individuals with certainty. No otters were photographed during the study.

Discussion

There is an opportunity cost involved in the placement of camera traps; deploying cameras facing the water to capture river otter, for example, will greatly decrease the probability of capturing non-aquatic species. Some target mammals, such as tayra and a grisson, were photographed along the shores of the rivers; however, fewer photos were captured in the selected locations than would have been if the cameras were deployed along trails. Due to a lack of both manpower resources and the distant isolation of camera placement sites it was difficult to move cameras in response to field data collection. Had it been possible to adjust camera placement in response to site discoveries, such as the discovery of scat or a shelter, it would have increased the chances of capturing river otter. Many empty photos resulted from the cameras' sensitivity to sunlight reflecting off of the water surface. This is a common phenomenon with camera traps (Long et al. 2012) that resulted in a need for additional labor hours to change memory cards more frequently and to sort through the photos.

Prior to any camera trap project it is essential to, if not run a pilot study then, at least investigate the study area. Many projects occur in remote areas with limited access (Ancrenaz et al 2012). For river otter especially the success of a camera trap survey may depend on prior knowledge of latrine sites (Stevens et al. 2004). It is also valuable to understand the demographic of the local communities and to inform them of the project's purpose and benefits to avoid damage or loss of cameras. Two cameras were stolen during the study and were replaced by others from a different project. Members of small communities are often suspicious of surveillance equipment and education them to alleviate their suspicion is a tactic that prevents their interference with the equipment.

The Neotropical river otter is extremely elusive and has a small density in this area according to local recounts. The sampling effort of this study was therefore too small to capture the species. The study was conducted over 52 days and the standard for conclusive evidence that an animal is absent from a site is 1000 trap days (Carbone et al. 2001). Although no Neotropical river otters were captured on camera the results of the study are inconclusive due to insufficient sampling effort. A greater number of cameras deployed for a longer period of time, or for multiple interludes would increase the probability of success. Similar results were obtained by Srbek-Araujo and Chiarello (2005) despite that they report this species of otter existing in previous records. Although other researchers have succeeded in using camera traps to study other river otter species (Stevens et al. 2004, Stevens and Serfass 2005, Olson et al. 2005), the cameras were ineffective for this study due to lack of laborers, local interference, deficient sampling effort, and lack of knowledge as to the location of latrines.

References

Ancrenaz, M., A. J. Hearn, J. Ross, R. Sollmann & A. Wilting, 2012. Handbook for Wildlife Monitoring Using Camera-traps. BBEC Publication, Sabah Parks and Japan International Cooperation Agency

Baldwin, R. A., & Bender, L. C. (2008). Distribution, occupancy, and habitat correlates of American martens (Martes americana) in Rocky Mountain National Park, Colorado. Journal of Mammalogy, 89(2), 419-427.

Carbone, C., Christie, S., Conforti, K., Coulson, T., Franklin, N., Ginsberg, J. R., ... & Lynam, A. (2002). The use of photographic rates to estimate densities of cryptic mammals: response to Jennelle et al. Animal Conservation, 5(2), 121-123.

Cutler, T. L., & Swann, D. E. (1999). Using remote photography in wildlife ecology: a review. Wildlife Society Bulletin, 571-581.

Farhadinia, M. (2004). The last stronghold: cheetah in Iran. Cat News, 40, 11-14.

Karanth, K. U. (1995). Estimating tiger Panthera tigris populations from camera-trap data using capture—recapture models. Biological conservation, 71(3), 333-338.

Kelly, M. J., & Holub, E. L. (2008). Camera trapping of carnivores: trap success among camera types and across species, and habitat selection by species, on Salt Pond Mountain, Giles County, Virginia. Northeastern Naturalist, 15(2), 249-262.

Koerth, B. H., McKown, C. D., & Kroll, J. C. (1997). Infrared-triggered camera versus helicopter counts of white-tailed deer. Wildlife Society Bulletin, 557-562.
Mace, R. D., Minta, S. C., Manley, T. L., & Aune, K. E. (1994). Estimating grizzly bear population size using camera sightings. Wildlife Society Bulletin (1973-2006), 22(1), 74-83.

Linkie, M., Chapron, G., Martyr, D. J., Holden, J., & Leader-Williams N.(2006). Assessing the viability of tiger subpopulations in a fragmented landscape. Journal of Applied Ecology, 43(3), 576-586.

Liu, X., Wu, P., Songer, M., Cai, Q., He, X., Zhu, Y., & Shao, X. (2013). Monitoring wildlife abundance and diversity with infra-red camera traps in Guanyinshan Nature Reserve of Shaanxi Province, China. Ecological indicators, 33, 121-128.

Long, R. A., MacKay, P., Ray, J., & Zielinski, W. (Eds.). (2012). Noninvasive survey methods for carnivores. Island Press.

Lyra-Jorge, M. C., Ciocheti, G., Pivello, V. R., & Meirelles, S. T. (2008). Comparing methods for sampling large-and medium-sized mammals: camera traps and track plots. European Journal of Wildlife Research, 54(4), 739-744.

Mace, R. D., Minta, S. C., Manley, T. L., & Aune, K. E. (1994). Estimating grizzly bear population size using camera sightings. Wildlife Society Bulletin (1973-2006), 22(1), 74-83.

MacKenzie, D. I., & Royle, J. A. (2005). Designing occupancy studies: general advice and allocating survey effort. Journal of Applied Ecology, 42(6), 1105-1114.

Martínez, Ana María & Saker, Chris. (2012). Las Nubes: Conservation in the Cloud Forests of Costa Rica. Rainforest Editions. York University Bookstore.

Olson, Z. H., Stevens, S. S., & Serfass, T. L. (2005). Do Juvenile Nearctic River Otters (Lontra canadensis) Contribute to Fall Scent Marking?. The Canadian Field-Naturalist, 119(3), 459-461.

Rapson, A., Bunch, M., & Daugherty, H. (2012). A decade of change: assessing forest cover and land use trends in the Alexander Skutch Biological Corridor, Costa Rica. Revista Latinoamericana de Conservación| Latin American Journal of Conservation, 3(1).

Rowcliffe, J. M., & Carbone, C. (2008). Surveys using camera traps: are we looking to a brighter future?. Animal Conservation, 11(3), 185-186.

Srbek-Araujo, A. C., & Chiarello, A. G. (2005). Is camera-trapping an efficient method for surveying mammals in Neotropical forests? A case study in south-eastern Brazil. Journal of Tropical Ecology, 21(01), 121-125.

Stevens, S. S., Cordes, R. C., & Serfass, T. L. (2004). Use of remote cameras in riparian areas: challenges and solutions. IUCN otter specialist group bulletin A, 21.

Stevens, S. S., & Serfass, T. L. (2005). Sliding Behavior in Nearctic River Otters: Locomotion or Play?. Northeastern Naturalist, 12(2), 241-244.

Schipper, J. (2007). Camera-trap avoidance by Kinkajous Potos flavus: rethinking the "non-invasive" paradigm. Small Carnivore Conservation, 36, 38-41.

Van Schaik, C. P., & Griffiths, M. (1996). Activity periods of Indonesian rain forest mammals. Biotropica, 105-112.

Zielinski, W. J., Truex, R. L., Schlexer, F. V., Campbell, L. A., & Carroll, C. (2005). Historical and contemporary distributions of carnivores in forests of the Sierra Nevada, California, USA. Journal of Biogeography, 32(8), 1385-1407.